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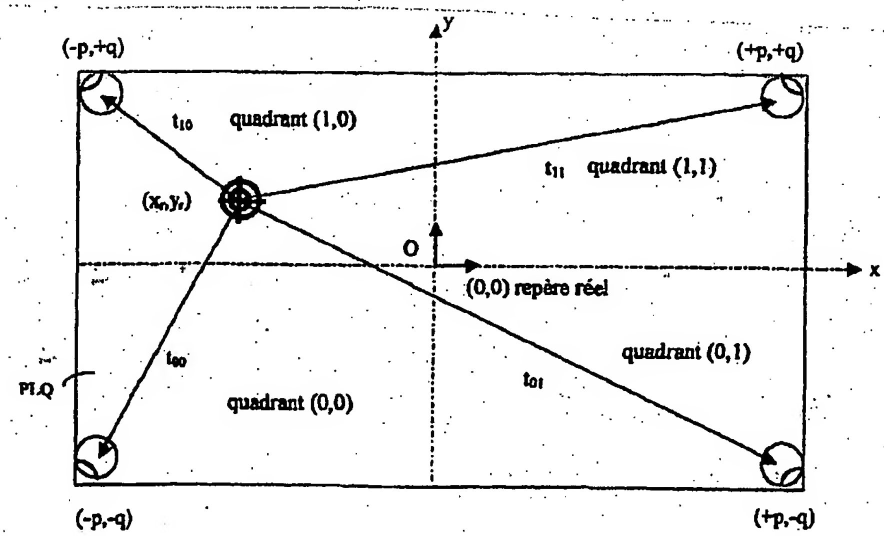

(57) Abstract: The invention relates to a device for acquiring the position co-ordinates of a mechanical wave source optionally generated by impacting the surface of a plate (PLQ) of finite size comprising a set of acoustic sensors (PZT00 to PZT11) each formed by a pair of piezoelectric transducers (PZTa,PZTb) facing each other on either side of the plate, the device including processing means for determining the co-ordinates of the source by analyzing the difference in propagation time of the acoustic waves generated by the source to different sensors. Said device is characterized by the fact that the processing means comprise combined with each sensor (PZT00 to PZT11) a respective electronic circuit including means mounted in cascade for digitizing the amplified signal around a pre-determined frequency, associated with means for limiting the digitization to a time window starting before the acoustic waves reach a sensor and ending when said acoustic waves reached said sensor.

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ACCURATE INTERACTIVE ACOUSTIC PLATE

The invention in general relates to devices for interactive communication between a user and a machine.

More precisely, the invention relates to a device for collecting and processing acoustic waves transmitted by a user or a sensor to a plate used as interface with a machine. Said device analyzes propagation time of acoustic waves in the plate especially for measuring the impact co-ordinates $x_r y_r$ on the plate surface.

A device for acquiring co-ordinates $x_r y_r$ of a point on rigid plate is known through world patent WO 96/11378, from which a source punctually emits wave packs. These co-ordinates $x_r y_r$ are acquired by analyzing the propagation time of acoustic waves in the plate in two directions x and y of the plate.

It is also known through French patent 98/16229 of December 22, 1998 an acquisition device wherein two pairs of transducers are respectively associated with each direction x, y. The device for acquiring the position of the source according to each direction, which is determined by measuring the arrival time difference of wave packs to two respective pairs of transducers of said direction.

These two acquisition devices are particularly well adapted to the selective detection of an acoustic Lamb mode in an isotropic glass plate. Particularly, the device in patent 98/16229 proposes a process for quantifying the intensity of an impact permitting it to attain a precision of 1% in the measurement of position. The present invention shows how to again improve this result, this fact is necessary if one wants to point with reliability areas in the size of one square centimeter on a plate of four to ten square meters. Furthermore, devices described in above-mentioned patents are not much reliable when the plate is made of laminated glass i.e. an assembly of two or more simple or re-baked or quenched glass panes, intimately bonded together with interposition of one or several polymer films such as polyvinyl butyl. For security reason, use of laminated glasses is more and more often required in public area. In case of break, the polymer constitutes an armature to which glass

shards remained bonded; this fact allows the laminated glass insuring a residual protection before its replacement.

Use of laminated glass for making acoustic tiles operating in the principle of localizing the impact by measuring the propagation time of the ultrasound plate modes requires an improvement of the devices described in previous patents.

The present invention purpose is to improve the quality and reliability of the reception of acoustic waves in a device simultaneously adapted to simple isotropic or laminated plates. Particularly, the invention will show how to improve the measurement precision by making the latter more independent from the shock intensity.

Another purpose of the present invention is to also improve the device ergonomy especially with an automated calibration of the plate permitting one to take into consideration the temperature effects on propagation speed of acoustic waves and therefore on the precision as well as with the establishment of a simpler and more rapid homothetic correspondence between real co-ordinates of an impact on the plate and screen co-ordinates of a graphic interface directly projected to the plate with a video projector, size of said graphic interface being able to rapidly vary in function of an intended or accidental motion of the video projector.

The invention also aims to improve communication means available to the user in order to emulate the activation principle by an impact, operation of a mouse type pointer or an alphanumeric keyboard necessary to the search of information in the Internet.

Finally, the invention shows how to mask the impact noises to a window with a superposition process of a synthesized sound over a sound issued from an impact.

To attain these goals, the invention proposes a device for acquiring co-ordinates of interaction points of an acoustic source with the plate surface, eventually laminated, of finite size, comprising a set of acoustic sensors each formed with a pair of piezoelectric

transducers located in opposition on either side of the plate, the device comprising processing means for determining co-ordinates of said interaction point by analyzing the difference of propagation time of acoustic waves emitted by the source to different sensors, device characterized by the fact that processing means comprise is association with each sensor a respective electronic circuit comprising in cascade means for making wide band pre-amplification, selective amplification means centered on a first pre-determined frequency, means for detecting the head of wave pack and for sampling the signal on a temporal window comprising the wave pack head as well as means for commuting sensors into transmitter or receiver in order to determine the ultrasound wave propagation speed or to conduct an integrity control of the plate, as well as means for calibrating the automated acquisition system and therefore simple for the user.

Preferred but non-limiting aspects of the device according to the invention are as follows:

- Sensors are in the number of four and piezoelectric transducers of each sensor are piezoelectric ceramic disks bonded to either side of the plate, such that four sensors form the apexes of a rectangle whose center is the origin of co-ordinates,
- The rectangle defined by sensors are divided into four quadrants, each quadrant being associated with a triplet of sensors nearest to the center of the quadrant in charge of t detecting impact co-ordinates in this quadrant with a measurement precision better than the one that would be obtained with other triplets,
- The piezoelectric ceramic disks have silver-plating return allowing one to make electrical connections on the same disk surface,
- Piezoelectric disks are of the ferro-electric type,

- The silver-plating return preferably has cylindrical symmetry. When the silver-plating return does not respect the cylindrical symmetry, it is positioned such that the sensor has the most omnidirectional sensitivity possible.
- Electrical connections of two piezoelectric transducers of each sensor are connected in parallel, polarization vectors being symmetrically mounted relative to the median plane of the plate such that slower non-symmetrical modes are discriminated and the more rapid symmetrical modes, privileged.
- Localization of an impact point with laminated glass made up with an assembly of two identical plates, each has thickness e, connected one to the other with a polymer film, consists of extracting the ultrasound component frequency f_c satisfying to the rule: $f_c \cdot e = 1.2$ MHz.mm, said frequency being generated by the impact of a hard object such as the flat part of a finger nail, a metal key, a hard plastic stick,
- Localization of an impact point on the plate in one of the four quadrants defined by the bit couple (g_y, g_x) consists of measuring the difference in propagation time between two sensors, taken from a triplet of sensors, defining a first direction and two sensors, taken from the same triplet of sensors, defining a second direction perpendicular to the first one, such that Cartesian co-ordinates of the impact point (x_r, y_r) on the plate are provided by the formula:

$$x_r = (-1)^{g_x} \frac{\Delta t_{xy}\left(q\sqrt{p^2 v^2 (4p^2 - v^2 \Delta t_{xy}^2)(4p^2 + 4q^2 - v^2(\Delta t_{xy} - \Delta t_{yy})^2)\Delta t_{yy}^2 (4q^2 - v^2 \Delta t_{yy}^2)} + p^2 v^2 \Delta t_{yy}^2 (-4q^2 + v^2 \Delta t_{yy}(-\Delta t_{xy} + \Delta t_{yy}))\right)}{4p\,\Delta t_{yy}(q^2 v^2 \Delta t_{xy}^2 + p^2(-4q^2 + v^2 \Delta t_{yy}^2))}$$

$$y_r = (-1)^{g_y} \frac{q v^2 \Delta t_{xy}(-4p^2 + v^2 \Delta t_{xy}(\Delta t_{xy} - \Delta t_{yy}))\Delta t_{yy} + \sqrt{p^2 v^2 (4p^2 - v^2 \Delta t_{xy}^2)(4p^2 + 4q^2 - v^2(\Delta t_{xy} - \Delta t_{yy})^2)\Delta t_{yy}^2 (4q^2 - v^2 \Delta t_{yy}^2)}}{4(q^2 v^2 \Delta t_{xy}^2 + p^2(-4q^2 + v^2 \Delta t_{yy}^2))}$$

wherein, p and q are two positive numbers respectively representing x co-ordinate and y co-ordinate of the sensor position relative to the rectangle center defined by the sensors, v the velocity of the detected plate mode, i.e., for a laminated glass,

the velocity of the most rapid mode, Δt_{xg} (respectively Δt_{yg}) the difference in propagation time of the wave pack generated by the impact, between the sensors of the first pair located in the half-rectangle g_x (respectively of the second pair located in the half-rectangle g_y),

- Determination of the sensor triplet associated to a given impact is done according to an algorithm searching the largest difference of propagation time available between sensors in two perpendicular directions,
- Said electronic circuits associated with sensors comprise in cascade a wide band pre-amplifier stage, a selective amplifier stage in the ultrasound band, a square exponentiation stage, a crest detecting stage, an integrating stage, an adaptation to a logic level stage making up with synchronization signal "SYNC" designed on the one hand for approximately calculating the position of an impact, on the other hand for controlling the stop of digital recording of the signal associated with the sensor, and on the other hand again for starting of the procedure of sound enrichment, described here-after,
- Electronic circuits associated to respective sensors comprise downstream said selective amplification means, synchronous analog digital converters associated to FIFO (first in – first out) memories sufficiently large to digitize the equivalent of several acoustic periods of the selected frequency, such to have a digital recording starting before the arrival of wave pack head, said digitization of the signal being characterized by a sampling frequency of at least 1 MHz,
- Difference in propagation time between sensors is deduced, on the one hand, from time intervals between synchronization signals, on the other hand, from time intervals separating synchronization signals of the wave pack head,

– Electronic circuits associated with respective sensors comprise upstream of said selective amplification means a derivation toward digitization, analysis means, and means for frequency enrichment of the audible acoustic signal generated by the impact to the plate, as well as means for re-converting the enriched digital signal into analog signal and to send it to the speakers such to mask nuisance created by the impact with a more pleasant sound reproducing for example the sound of percussion instrument in the heart of a symphonic composition, or the sound of an animal or a natural event, said enrichment means being used at the same time where the first of four synchronization signals is activated,
– Measurement of the time interval separating a synchronization signal of the associated wave pack head consists of determining the time of passage to zero of the digitized signal rising with time from the commutation time defined by SYNC, while a test of the sum of amplitudes between passages to zero, i.e. a test of the signal average value per half-period, decides the continuation of the algorithm. When the average value per half-period is equal to the output value of the sampler in the absence of signal, within a threshold deviation, the algorithm is stopped, and the average value is considered as being the origin time t_{HD} of the pack.
– At least one of the sensors is suited to be commuted into transmitter of a ultrasound wave pack detected by the other sensors whose positions are finally known in order, on the one hand, to automatically measure the ultrasound propagation speed, dependent from the temperature, on the other hand, to trigger an integrity test of the plate, by measuring the difference in propagation time of a wave pack between different sensors,

- The administration of all steps of measurement, processing and transfer of data with an interface of communication in series, either to a LCD display screen, or to an interface for musical instrument (interface MIDI), or to a more powerful calculator such a micro-computer via its RS232 or USB ports is controlled by a micro-controller,
- The device constitutes a peripheral interface with a machine, which receives signals issued from processing means and which, in function of said signals, controls the execution of files contained in the computer with various known type peripherals connected to the computer such as for example in a non-limiting way a video projector, luminous sources, speakers, printers, or again an automated box controlling mechanical action such as closing a protective curtain,
- The system has software means for emulating the operation of another peripheral such as a mouse type pointer or a keyboard and constitutes a peripheral interface with the computer, which controls, in function of signals issued from processing means, the execution of files contained in the computer or, through a modem or a network card, the execution of files contained in a remote server,
- The computer is associated with large size flat screen or, better, with a computerized video projector projecting to a portion named screen zone of the plate surface whose one of the surfaces is at least made of frosted glass, information available from an Internet port,
- The frosted surface may be replaced with the placement of a diffusing film, eventually in combination with a Fresnel lens playing the role of directional magnifier, i.e. of directional concentrator of the light allowing one to use the graphic interface, even in daylight,

- The device has software means permitting one to make appear, reduce or move a keyboard in the screen zone,
- The device has software means permitting one to automatically establish rapid and simplified homothetic correspondence between real physical co-ordinates in millimeter of an impact and graphic co-ordinates in pixels of this impact when it is produced inside the graphic zone. Axes of graphic and real co-ordinate systems are parallel and said software means provide the following operations:
  - The software displays a target in various positions of known graphic co-ordinates and measures the corresponding real co-ordinates. For example, a first target is displayed in $N_0(i,j)$ wherein i and j are screen co-ordinates near the screen origin. This target is displayed on an acoustic plate with real co-ordinates $N_0(x_a,y_c)$. An impact realized at a location where the target appears allows one to collect these real co-ordinates via the acquisition card. A second target of screen co-ordinates $N_1(k,l)$ is then displayed near the screen maximal co-ordinates. Corresponding real co-ordinates $N_1(x_b,y_d)$ are obtained with an impact facing the target.
  - Graphic co-ordinates (N_{qx},N_{qy}) of any point Q with real co-ordinates (x_r,y_r) may then be deduced from the formula:

$$\left\{\begin{array}{l} N_{qx}=i+(k-i)\dfrac{(x_r-x_a)}{(x_b-x_a)} \\ N_{qy}=j+(l-j)\dfrac{(y_r-y_d)}{(y_c-y_d)} \end{array}\right\}$$

  - A reference target is displayed one last time at the graphic screen center. The impact made in opposition of the target is converted into screen co-ordinates according to the above formula. The calculated position is compared to the reference position. If the deviation is lower than a certain

threshold, the calibrating operation is validated. Otherwise, it is re-calibrated,

- The device has software means so that the plate portion, which is not used as a screen is also interactive and is configured as an extension of the screen zone, particularly an impact made to the left (respectively, to the right, above, below) of the screen zone moves the screen content to the right (respectively, to the left, below, above), thus allowing one to read the document with size much larger than that of the screen zone,
- The device has software means such that the plate portion used as screen is considered as a special zone allowing one to leave or to commute any software application into administration of the execution of program groups associated with various zones of the plate located outside the screen,
- Inversely, the system has software means so that all impact made to the plate outside the screen zone is associated with the execution of a chosen application wherein, from the homothetic correspondence established between pixels of a digital photo of the acoustic plate and physical co-ordinates of these pixels on the acoustic plate, program groups are executed consecutive to an impact to a given zone of the plate.

Other aspects, purposes and advantages of the present invention will appear better at the reading of following detailed description of preferred embodiments of the invention, provided as non-limiting example and with reference made to annexed drawings, wherein:

Figure 1 is schematic view of a rectangular plate providing the location and co-ordinates of sensors, real references and defined graphics as well as real and graphic co-ordinates of three impacts to the plate.

Figure 2A is a screen picture of a dialog box allowing one to configure the graphic interface and to define the authorized zone wherein impacts are interpreted as events of the mouse-type pointer.

Figures 2B to 2F are screen pictures of the calibration procedure of the graphic interface permitting one to establish the homothetic correspondence between physical co-ordinates and screen co-ordinates of the plate portion playing the role of a screen.

Figure 3A is a screen picture of principal keys of an alphanumeric keyboard occupying about the whole width of graphic screen and about 1/3 of its height. Keyboard is enriched with two additional keys allowing one to move or reduce its size at two floating buttons according to figure 3B.

Figure 4 is a chronogram of principal measurement steps of the difference in transit time between two sensors.

Figure 5A is a block schema of the general architecture of acquisition card conceived on the basis of analog and digital circuits with, particularly, the use of a micro-controller capable of processing data for the calculation of the wave pack arrival time and the transfer of data with a communication protocol in series to a micro-computer or another device.

Figure 5B is an electrical schema of module PMP of figure 5A and shows a generator delivering high voltage HT using a diode pump, synchronous with the micro-controller system clock.

Figure 6 is a schematic cross-sectional view of the symmetrical mounting of piezoelectric transducers of a sensor deigned to detect the S_0 mode corresponding to the most rapid vibrations propagating itself in a laminated glass.

Figures 7A and 7B show signals issued from transducers of figure 6 in response to an impact distant of 70 cm (figure 7a) and 130 cm (figure 7b), after the selective amplification around100 kHz.

Figure 7C shows in more details the loss of symmetry observed with modes S_0 detected by transducers PZTb and PZTa in figure 6 in the case of a laminated glass made up with an assembly of two plates of 6 mm thick taking in sandwich a polymer film.

Figure 8 is a principle schema of a detection device with 3 sensors glued in the corners allowing one to liberate the plate sides.

Figure 9 shows the uncertainty of localizing an impact in the plate nine locations of the device in figure 8 when detection of the wave pack arrival time is known to within 1µs.

Figure 10 is a schematic view indicating the transit time between an impact and the sensors of a four sensor detection system functioning with triplets of sensors operating each on a given quadrant of the plate.

Figure 11 is a block schema of one part of the internal architecture of the programmed component "wavepro4" of figure 5.

First, with reference made to figure 1, a plate PLQ is shown and comprises four pairs PZT00, PZT10, PZT01, PZT11 of piezoelectric transducers, which make up each an acoustic sensor, two transducers of each pair being fixed in opposition on two opposite surfaces of the plate, for example with bonding for collecting acoustic waves circulating in the plate. At the difference of the plate described in patent 98/16229, direction of electrical polarization and electrical connections are respectively symmetrical relative to the plate median plane and non-parallel or non-symmetrical relative to the median plane such to discriminate any non-symmetrical propagation mode and to privilege any symmetrical propagation mode.

An x,y perpendicular system with origin O is associated with plate PLQ, the plate center being able to coincide with reference origin O. Four sensors make up the apexes of a rectangle. Axes x and y cross the middle of the sides. PZT00, PZT10, PZT01, PZT11 have respective co-ordinates (-p,-q) and (-p,+q), (+p,-q), (+p,+q). Acoustic waves may be generated by the shock of an object to the plate. The plate is an assembly of at least two

isotropic plates each made of rigid material making up good isotropic acoustic conductor around 100 kHz such as glass. Plates are rigidly bonded to each other with a polymer film such as the polyvinyl butyl or PVB. Polymer film thickness is ranging from 1 to 2 millimeters. Its acoustic impedance is small compared to that of the glass such that we will continue to suppose in this description, with first approximation, that each of the plates making up the laminated glass is capable of propagating symmetrical and non-symmetrical Lamb waves. During the propagation within laminated glass, the modes propagate in one plate and from one plate to the other of the laminated glass. A shock produced at the surface of the laminated glass gives birth in the plates to coupled symmetrical modes as well as coupled non-symmetrical modes. Taking into consideration the material motion vectors, which characterize them, non-symmetrical modes are more attenuated by the PVB relative to symmetrical modes, as the acoustic frequency is low. Figures 7A and 7B clearly show this relative phenomenon of attenuation more important for non-symmetrical modes: signals that are independently collected by transducers PZTa and PZTb in figure 6 after selective amplification at 100 kHz. Signals in figure 7A are response to a shock generated at a distance of 0.7 m, while signals of figure 7B are response to a shock generated at 1.3 m. Although more efficiently generated than symmetrical modes, the most dispersive propagation of non-symmetrical modes combined to the attenuation by PVB degrade more rapidly the non-symmetrical wave pack head. That is why it is preferable to privilege the detection of symmetrical modes when laminated glass is used.

Furthermore, the applicant has observed that the mounting of sensors for detecting non-symmetrical modes and the rejection of symmetrical symbols as it is described in patent 98/16229 and WO/11378 are useless with laminated glasses. In fact, as it can be seen with the curves of figure 7C obtained with a shock to laminated glass made up with 2 glass plates of 6 mm thick rigidly bonded with a PVB film of 2 mm thick according to the mounting of figure 6, S_0 modes of upper and lower plates are no longer completely in

opposition of phase, such that it is no longer possible to efficiently discriminate mode S_0 and that regardless of the shock intensity, according to known methods described in previous patents.

The present invention purpose is to show how to reliably detect symmetrical modes. For that, the invention proposes conserving a two-transducer mounting in opposition according to the symmetrical mounting and electrical connections in parallel of transducers PZTa and PZTb in figure 6, to ensure this time the discrimination of larger amplitude non-symmetrical modes near the receivers. Furthermore, consideration should be taken by the fact that intensity and phase of symmetrical modes depend on the impact angle to the window. Forms of waves recorded by the receivers are therefore largely variable. For the non-symmetrical modes, they are reduced in amplitude and change their form according to dispersion curves characterizing the Lamb modes, i.e. mechanical waves associated with audible frequencies have a phase and group speeds lower than mechanical waves associated with the highest ultrasound frequencies. The effect of this fact is to renew the form of the wave pack head and reveals higher and higher frequency components during the propagation. It is not the case for symmetrical modes whose waveform is conserved because they are not very much dispersive for the considered ultrasound frequencies and the thickness of the anticipated plate.

If one uses the processing signal described in the French patent 98/16229 relating to wide band amplification followed with a square exponentiation followed with a crest detection then an integration, it appears that this process is the foundation of the detection of the wave pack arrival time based on the obtaining of an energy threshold level. Now, the more the sensor is distant from the impact position, the more it is reduced in amplitude, this fact implies longer integration time before attaining this threshold level. This integration time will depend then on the shock intensity as well as the nature and form of the impacting object. This fact will show up at the procedure end with uncertainty on the impact position.

To remedy this disadvantage, the present invention proposes a modification of the method for detecting the wave pack arrival time. This modification consists of conducting a measurement in two steps. The first step is the same as the method known in patent 98/16229 whose principle is just reminded. It allows one to determine with a first approximation of the wave pack arrival time and supplies synchronization signals for the second step. The new second step consists, for each sensor, of permanently sampling output signal of the selective amplifier centered on high ultrasound frequency of around 100 kHz, and saving the samples in a FIFO memory (first in, first out) with sufficient capacity to store the equivalent of 10 acoustic periods. Typically, for a sampling frequency of 1 million samples per second (1 MSPS) and a central filter frequency of 100 kHz, the FIFO memory capacity will be 128 samples. Continuous calibration is independently done for each sensor pair. Sampling of the signal is stopped by the synchronization signal. Content of FIFO memory, then frozen, contains digital recording of the wave pack head. Analysis of this content, conducted later in this description, provides the time interval between synchronization signal and wave pack head allowing one to independently rise the signal amplitude or phase, at the wave pack arrival time. Measurement precision of this time is then only imposed by the sampling frequency, the signal/noise ratio and the number of quantification bits.

During the first step, the promptest receiver to reach the detection energetic threshold of the component at 100 kHz defines the time origin and triggers an enumeration of time until the wave pack arrival to other receivers.

This recording of events may eventually be reconsidered during the second step, in this case when the difference in propagation time is very small.

Figure 1 configuration suits well when it is desirable to have a plate with free edges. However, it is enough with three pairs of sensors to determine the impact co-ordinates. Figure 8 illustrates this detection principle with three sensors forming a rectangular triangle. Axes of physical reference as well as its origin remain unchanged relative to the configuration with four sensors in figure 1. With the difference of transducers described in previous patents, transducers of the present invention have silver-plating return allowing one to make connections on the same surface of the sensor and subsequently the bonding with a fluid insulating adhesive. Measurements of difference in transit time of a wave pack are preferably done in two orthogonal directions. Several configurations with three sensors forming rectangular triangle may be extracted from the configuration with 4 sensors of figure 1. Four configurations described later lead to identical mathematical solutions, within a sign, for an impact co-ordinates (x_r, y_r). Furthermore, each of these configurations is better adapted than the others, from the precision stand point of measurement, if it is only used on one given quadrant of the plate. To appreciate it, take a configuration with three sensors PZT00, PZT10, PZT11 corresponding the schema of figure 8 and look at the uncertainty obtained on the impact position when the uncertainty on the wave pack arrival time is within1 µs for a wave pack moving with a speed of 3350 m/s. Figure 9 illustrates this uncertainty with full rectangles whose size, provided in millimeter, is displayed in nine different locations of a plate of 1400 mm x 800 mm size. It is noted that the uncertainty on the impact position remains smaller than 7 mm^2 in the quadrant (1,0) while it attains 80 mm^2 in the quadrant (0,1). Therefore, it is advantageous to restrain the use of the configuration of figure 8 to only one quadrant, quadrant (1,0). However, the same precision may be obtained with other quadrants if the detection triplet is changed when the impact changes the quadrant.

So, for a given impact, the quadrant (g_y,g_x) to which it belongs is determined first, then co-ordinates (x_r,y_r) are calculated according to the formula associated with this quadrant.

Figure 10 shows a rectangular plate with four pairs of sensors with silver-plating return bonded in the corners, silver-plating returns being directed such that the angular response of sensors is the most uniform possible for a reception angular range of $\pi/2$. Sensors also form a rectangle and allow one to define a Cartesian reference, whose center is the rectangle center formed with sensors and whose axes pass by the middle of the sides similarly to the one in figure 1. Cartesian co-ordinates of sensors are (-p,-q), (-p,+q), (+p,+q), (+p,-q). Acoustic waves move with a speed v. Propagation time up to sensors of a wave pack generated by an impact in (x_r,y_r) is t_{00}, t_{01}, t_{10}, t_{11}.

Co-ordinates (x_r,y_r) are obtained by resolving a system of equations, valid for a given quadrant. The four systems of equations are:

- $(g_y, g_x) = (0,0)$. $x_r < 0$ et $y_r < 0$

$$\begin{cases} v(t_{01}-t_{00}) = v\Delta t_{xg} = v\Delta t_{x0} = \sqrt{(x_r-p)^2+(y_r+q)^2} - \sqrt{(x_r+p)^2+(y_r+q)^2} \\ v(t_{10}-t_{00}) = v\Delta t_{yg} = v\Delta t_{y0} = \sqrt{(x_r+p)^2+(y_r-q)^2} - \sqrt{(x_r+p)^2+(y_r+q)^2} \end{cases}$$

- $(g_y, g_x) = (0,1)$. $x_r < 0$ et $y_r > 0$

$$\begin{cases} v(t_{11}-t_{10}) = v\Delta t_{xg} = v\Delta t_{x1} = \sqrt{(x_r-p)^2+(y_r-q)^2} - \sqrt{(x_r+p)^2+(y_r-q)^2} \\ v(t_{00}-t_{10}) = v\Delta t_{yg} = v\Delta t_{y0} = \sqrt{(x_r+p)^2+(y_r+q)^2} - \sqrt{(x_r+p)^2+(y_r-q)^2} \end{cases}$$

- $(g_y, g_x) = (1,0)$. $x_r > 0$ et $y_r < 0$

$$\begin{cases} v(t_{00}-t_{01}) = v\Delta t_{xg} = v\Delta t_{x0} = \sqrt{(x_r+p)^2+(y_r+q)^2} - \sqrt{(x_r-p)^2+(y_r+q)^2} \\ v(t_{11}-t_{01}) = v\Delta t_{yg} = v\Delta t_{y1} = \sqrt{(x_r-p)^2+(y_r-q)^2} - \sqrt{(x_r-p)^2+(y_r+q)^2} \end{cases}$$

$(g_y, g_x) = (1,1)$. $x_r > 0$ et $y_r > 0$

$$\begin{cases} v(t_{10}-t_{11}) = v\Delta t_{xg} = v\Delta t_{x1} = \sqrt{(x_r+p)^2+(y_r-q)^2} - \sqrt{(x_r-p)^2+(y_r-q)^2} \\ v(t_{01}-t_{11}) = v\Delta t_{yg} = v\Delta t_{y1} = \sqrt{(x_r-p)^2+(y_r+q)^2} - \sqrt{(x_r-p)^2+(y_r-q)^2} \end{cases}$$

Following formulas provide the impact position (x_r, y_r). It is enough to replace g_x and g_y with the value corresponding to the related quadrant.

$$x_r = (-1)^{g_x} \frac{\Delta txg \left(q \sqrt{p^2 v^2 (4 p^2 - v^2 \Delta txg^2)(4 p^2 + 4 q^2 - v^2 (\Delta txg - \Delta tyg)^2) \Delta tyg^2 (4 q^2 - v^2 \Delta tyg^2)} + p^2 v^2 \Delta tyg^2 (-4 q^2 + v^2 \Delta tyg (-\Delta txg + \Delta tyg)) \right)}{4 p \Delta tyg (q^2 v^2 \Delta txg^2 + p^2 (-4 q^2 + v^2 \Delta tyg^2))}$$

$$y_r = (-1)^{g_y} \frac{q v^2 \Delta txg (-4 p^2 + v^2 \Delta txg (\Delta txg - \Delta tyg)) \Delta tyg + \sqrt{p^2 v^2 (4 p^2 - v^2 \Delta txg^2)(4 p^2 + 4 q^2 - v^2 (\Delta txg - \Delta tyg)^2) \Delta tyg^2 (4 q^2 - v^2 \Delta tyg^2)}}{4 (q^2 v^2 \Delta txg^2 + p^2 (-4 q^2 + v^2 \Delta tyg^2))}$$

Determination of measuring quadrant associated with an impact depends on differences in propagation time between the four sensors. Figure 4 illustrates steps of measurement of the difference in propagation time in the "y" direction from sensors PZT00 and PZT10 and the acquisition card described according to the block schema of figure 5. Represented signals are:

- output signals from selective filters centered on 100 kHz, FCH00 and FCH10,
- contents of memories FIFO10 and FIFO00 at low-high commutation time of synchronization logic signals SYNC10 and SYNC00.
- output signal of the square elevator SQ00
- signal INTGR00 at the output of integrator of the path associated with PZT00
- synchronization logic signal SYNC10 and SYNC00 at the output of PMOS00 and PMOS10
- time interval Δty_{S_0} separating synchronization signals
- time intervals TT10 and TT00 separating wave pack head of respective synchronization signals SYNC10 and SYNC00
- an enumerating frequency counter identical to that of signal sampling and triggered by the logic signal SYNC10.

Signals relating to two other sensors PZT01 and PZT11 are not shown, but they supply similar signals in their own acquisition path.

In general, and with reference made to what was said above, differences in propagation time between sensors, provided in number of clock periods XBUF are determined according to following formulas and symbols:

#, designates a logic "or",

&, designates a logic "and",

abs, designates the absolute value,

•, designates the multiplication.

A bar above a symbol designates the inverse logic. Symbols SP00 to SP11 are outputs of scales D associated with signals SYNC00 to SYNC11 and passing to high logic state during a low-high transition of respective signals SYNC00 to SYNC11.

There are:

$$\begin{cases} \Delta t_{x0} = abs\left[TT_{01} - TT_{00} + (-1)^{SS_{x0}} \cdot XBUF \,\&\, \Delta tx_{S0}\right] \\ \Delta tx_{S0} = \left(\left(SP_{01} \,\&\, \overline{SP_{00}}\right) \# \left(\overline{SP_{01}} \,\&\, SP_{00}\right)\right) \\ \Delta t_{x1} = abs\left[TT_{11} - TT_{10} + (-1)^{SS_{x1}} \cdot XBUF \,\&\, \Delta tx_{S1}\right] \\ \Delta tx_{S1} = \left(\left(SP_{11} \,\&\, \overline{SP_{10}}\right) \# \left(\overline{SP_{11}} \,\&\, SP_{10}\right)\right) \\ SS_{x0} = SP_{00} \,\&\, \overline{SP_{01}} \\ SS_{x1} = SP_{10} \,\&\, \overline{SP_{11}} \end{cases} \quad \begin{cases} \Delta t_{y0} = abs\left[TT_{10} - TT_{00} + (-1)^{SS_{y0}} \cdot XBUF \,\&\, \Delta ty_{S0}\right] \\ \Delta ty_{S0} = \left(\left(SP_{10} \,\&\, \overline{SP_{00}}\right) \# \left(\overline{SP_{10}} \,\&\, SP_{00}\right)\right) \\ \Delta t_{y1} = abs\left[TT_{11} - TT_{01} + (-1)^{SS_{y1}} \cdot XBUF \,\&\, \Delta ty_{S1}\right] \\ \Delta ty_{S1} = \left(\left(SP_{11} \,\&\, \overline{SP_{01}}\right) \# \left(\overline{SP_{11}} \,\&\, SP_{01}\right)\right) \\ SS_{y0} = SP_{00} \,\&\, \overline{SP_{10}} \\ SS_{y1} = SP_{01} \,\&\, \overline{SP_{11}} \end{cases}$$

$g_x = 0$ if $\Delta t_{y0} > \Delta t_{y1}$ and $[TT_{10} - TT_{00} + (-1)^{SS_{y0}} \,.\, XBUF \,\&\, \Delta ty_{S_0}] < 0$

or if $\Delta t_{y1} > \Delta t_{y0}$ and $[TT_{11} - TT_{01} + (-1)^{SS_{y1}} \,.\, XBUF \,\&\, \Delta ty_{S_1}] < 0$

otherwise gx = 1

$g_y = 0$ if $\Delta T_{x0} \geq \Delta T_{x1}$ and $[TT_{01} - TT_{00} + (-1)^{SS_{x0}} \,.\, XBUF \,\&\, \Delta tx_{S_0}] < 0$

or if $\Delta t_{x1} \geq \Delta t_{x0}$ and $[TT_{11} - TT_{10} + (-1)^{SS_{x1}} \,.\, XBUF \,\&\, \Delta tx_{S_1}] < 0$

otherwise $g_y = 1$

FIFO10 and FIFO00 memories contain each a digitization of the wave pack head detected by respective sensors PZT10 and PZT00. The process for determining co-ordinates in two steps shows here the improvement that it provides: in fact, it was not possible with the analog detection system using an active integrator to have precise arrival time of the wave pack, simply because it is not possible to know the time that the active integrator uses to move from a positive saturated state close to +10V, in the absence of the signal, to a negative saturated state close to –10V with integration of the signal. During this transition, the signal passes at a given time above the commutation threshold THR of the transistor PMOS in charge of adapting this transition, to logic levels compatible with logic CMOS, characterized by a power voltage VCC, which can be equal to 5 volts. Commutation threshold of transistor PMOS is located around 1.5 volt above the VCC, i.e. 3.5 volts. Transition time TT of the integrator is then the commutation time from +10 V to +3.5 V triggered by the wave pack arrival. This time depends on the amplitude of the envelope of the quadratic signal SQ, the gain provided by the active integrator, as well as the operational amplifier own characteristics used for making the integrator. Although the integration time could be reduced by increasing the amplifier gain as well as by reducing the positive voltage of the saturated state, this configuration is confronted by the problem of compromise that has to be found between sensitivity and reliability. A too high gain would make the integrator commute upon a parasite signal, while a too low gain generates a precision loss due to a largely variable integration time between an impact with low intensity and an impact with strong intensity. By proceeding in two steps according to the present invention, integrator gain is sufficiently kept high to keep a good immunity to noise and the integration time corresponding to interval TT is known. Measurement of interval TT consists for example of rectifying the digitized signal, then creating an interpolation curve from the crest amplitude of the rectified digitized signal. Intersection of the interpolation curve with the time axis corresponding to the sampler output value in the absence of signal providing the

origin time t_{HD} of the pack. Another preferred solution for measuring interval TT, consists of starting from the synchronization time located at one end of the window and searching successive passage to zero times to the pack head. Times of passage to zero allow one to lock on the digitized signal period, while a test on the sum of amplitudes between passages to zero, i.e. per half-periods, decides the continuation of the algorithm. When the average value of a half-period is equal to the output value of the sampler in the absence of a signal, to within a threshold deviation, the algorithm is stopped and the average value is considered as being the origin time t_{HD} of the pack.

Now, with reference made to figure 5, each sensor is associated with an analog acquisition path. Paths associated with sensors PZT00, PZT01, PZT11 are equivalent. Analog paths are characterized by a wide band amplification A1 and A2 followed with a selective amplification FCH in the ultrasound band, followed with a derivation whose one path leads to an 8-bit analog/digital converter CAN with positive measurement range. Positive input voltages are obtained with a pass-haut filter and a polarization bridge made up with components Ca, Ra, Rb, Rc. The converter is piloted by control logic signal CTA issued from a micro-controller µC. Converter CAN powers the input of a FIFO memory. Memory data are transferred via a data 8-bit bus DATA and other control signals CTF, controlling the charge, discharge and reset to zero of memory pointers, the placement in high impedance of the output bus, signals for indicating the filling state of FIFO memory, with RAM memory of µC to be locally processed and/or to be transferred to another device or a more powerful calculator such as a micro-computer via a parallel or series communication port, which may be a USB, MIDI or RS232 port. Logic levels between the micro-controller and the microcomputer are adapted with an adapter of logic level LGCSHF. The other path issued from the derivation powers a square exponentiation stage followed with a detection stage of the envelope followed with an integrator stage powering transistor PMOS for adapting to a logic level CMOS.

The path associated with sensor PZT10 has in addition a high voltage block for commuting into emission mode. High voltage is produced by module PMP shown in the schema of figure 5b and comprising a diode pump D21 to D26 and capacitors C21 to C26 powered by the logic signal XHT whose high logic level is adapted to +12 volts with transistors T10 and T11 and the low logic level to –12 volts with transistors T12 and T13. Signal XHT is issued from a logic function "and' between the signal of clock system XBUF of micro-controller and the signal CGPP activated to high logic level when a procedure of the plate integrity test or that of the measurement of ultrasound propagation speed is triggered. Without validating by CGPP signal, high voltage module does not produce high voltage HT close to 70 V. Commutation block is administered by the programmed logic component wavepro4 in charge of creating the logic burst of excitation and enumerating the propagation time of acoustic waves between sensor PZT10 and other sensors. Programmed logic component wavepro4 is piloted by micro-controller µC. Programmed counters are powered by the same clock system frequency XBUF as that of the micro-controller. This frequency is also the sampling frequency of analog/digital converter CAN. The burst is obtained with logic signals SRC and SNK in charge of controlling the opening of commutation transistors SWHTC and SWHTK. Transistors CMRC and CMSH are respectively in charge of putting the sensor in receiving mode or in short-circuiting the input of the amplification analog path for protecting it from high voltage.

Block schema of figure 11 describes one part of the internal architecture of the programmed component wavepro4. The component has type D logic scales FF1 to FF4 triggered by synchronization signal SYNC00 to SYNC11. Logic combinations between the inputs of these scales validate scales FF5 and FF6 whose inputs are signals SSx_0 and SSx_1, while other logic combinations define logic functions Δtx_{S_0} and Δtx_{S_1} representing time intervals used for calculating the difference in propagation time between sensors. A logic

function "and" between the clock signal XBUF and functions Δtx_{S_0} and Δtx_{S_1} respectively power 12-bit counter ($Q0x_{11}\ldots Q0x_0$) and ($Q1x_{11}\ldots Q1x_0$) associated to 3-state output registers, each register being identified and activated by the address decoder (A3…A0). The 4 bits of strong weight of counters ($Q0x_{11}\ldots Q0x_0$) and ($Q1x_{11}\ldots Q1x_0$) share the same output register in the following order strong weight on the left: (($Q0x_{11}\ldots Q0x_8$), ($Q1x_{11}\ldots Q1x_8$)). Logic scales FF1 to FF4 and FF7, FF8 allow one to similarly reproduce logic functions SSy_0, SSy_1 and Δty_{S_0}, Δty_{S_1}, which, via a "and" logic with the clock signal XBUF, respectively power 12-bit counters ($Q0y_{11}\ldots Q0y_0$) and ($Q1y_{11}\ldots Q1y_0$) also associated with 3 state output registers. The 4 bits of strong weight of counters ($Q0y_{11}\ldots Q0y_0$) and ($Q1y_{11}\ldots Q1y_0$) share the same output register in the following order, strong weight on the left: (($Q0y_{11}\ldots Q0y_8$), ($Q1y_{11}\ldots Q1y_8$)).

All output registers share the same 8-bit data bus DATA. The component also creates logic functions IntHF and IntBF routed to output terminal of component wavepro4 and producing when they commute to high level, an interruption request detected by the micro-controller µC disposing the inputs provided for this effect. Function IntBF is created from type D logic scale FFBF. Clock input of the scale is issued from a selective amplifier stage FBF centered on 10 kHz or preferably on the upper part of audible spectrum delivering a signal adapted to the logic CMOS by the transistor NMOS10. Scale FFBF then validates the presence of spectral energy in the upper part of the audible spectrum. Logic function IntHF is created from logic "or" between outputs Q of scales FF1 to FF4 validating the presence of spectral energy in the ultrasound band around 100 kHz. Time interval separating interruptions IntHF and IntBF characterizes an impact on the plate. Taking into consideration the spectrum lowest frequency to which it is attached to, interruption IntBF always occurs after IntHF. When it does not occur or it occurs after a waiting period is over, the measurement is refused because it is capable of having been

caused by inadvertent ultrasound signal being propagated up to the plate through ground. Outputs Q of logic scales FF1 to FF4 are routed by means of logic ET with signal XBUF to the output terminals of component wavepro4 and form respective clock signals LDCK00, LDCK01, LDCK10, LDCK11. FIFO memories are thus frozen at commutation time of signals SYNCij, with i and j equal to 0 or 1.

Quantification of the impact intensity is conducted by directing the output signal of a selective high frequency amplifier, i.e. at the proximity of 100 kHz, for example that of FCH00 to a 12-bit impact counter, programmed in the component wavepro4 whose clock input CLKi is the signal FCH00 adapted to logic CMOS.

Micro-controller is preferably of architecture RISC. Its clock system XBUF is a multiple of the frequency 32768 Hz of quartz QRTZ. The micro-controller has counters/timers, several input/output ports operating with or without interruption, active RAM memory, PROM memory or electrically programmable memory EPROM or re-programmable FLASH type memory, means for programming in situ of the program code JTAG, as well as means for communicating in series with other devices. It has at least four sensing/comparing functions allowing one to date-record temporal events. Synchronization signals SYNC00, SYNC01, SYNC10, SYNC11 are particularly connected to sensing/comparing ports. Micro-controller has an arithmetic and logic unit allowing it to calculate Cartesian co-ordinates of the impact, as well as to quantify the impact intensity. This solution is considered when it is necessary to rapidly transmit intensity and position information relating to the impact. Particularly, it is possible to use acoustic plate as a piano or a bi-dimensional percussion instrument. A key corresponds then to a sound or an audiovisual event executed in a pre-defined way, when an impact is done on a given portion of the plate with more or less strong intensity. With this type of applications, a rapid response time is desired, typically less than ten milliseconds. Acoustic plate has small size,

in the order of 0.25 m^2. The micro-controller is then in charge of the whole processing operation as well as the communication of information (x_r,y_r, impact counters) via the MIDI interface defined for digital musical instruments.

According to another aspect of the invention, which can be optionally considered as independent from above-mentioned aspects, the invention proposes improving the ergonomy and comfort of use of the window by treating the sound nuisance problem caused by the impact of an object to the plate according to a masking process of the sound generated by the impact, with its synthesized sound triggered by IntHF. In fact, synchronization signals commute at the beginning of the audible sound generated by the percussion. Therefore, it is possible to advantageously use it to trigger a recording followed with a processing and a sound synthesis in real time, which will superpose to the impact noise, and which will be able to enrich its frequency content such to imitate a known sound, such as for example the sound of a percussion instrument, of an animal or a natural event or to produce a sound different from the sound generated by the impact. Synthesized sound will be able in certain space regions to oppose in amplitude to the sound produced by the impact such to reduce the noise intensity. By choice, it is possible to condition the emission of synthesized sound to the presence of the interruption IntBF, which is practically produced in less than 1 millisecond after the IntHF.

The system according to the invention comprises, as it was indicated, a computer, which receives signals issued from the processing electrical circuits. The computer may, in function of these signals, emulate the operations of certain peripherals such as for example a mouse-type pointer or a keyboard. When the acoustic plate is associated with large size screen such as plasma screen or video projector projecting the graphic interface to the surface of the acoustic plate, it is possible to establish a homothetic correspondence between the screen co-ordinates in pixels and the physical co-ordinates in millimeters of all impacts such that a graphic pointer appears at the screen opposite to the impact. This

correspondence must be able to be established knowing that positions relating to the video projector and the plate may accidentally change. For that, the invention proposes a simple and rapid calibration procedure of the interface. The procedure is done is five steps with reference made to figures 2B, 2C, 2D, 2E and 2F. The operator first ensures that graphic and physical Cartesian reference axes are co-linear and moves, as needed its video projector. Calibration procedure itself may then begin. Figure 2B is a display screen of the procedure. The operator must produce an impact to the plate for passing to the step illustrated at figure 2C. During this second step, a target appears on the screen. Target screen co-ordinates $N_0(i,j)$ are known and close to the origin of screen co-ordinates. The impact to the plate opposite to the target provides to the software corresponding physical Cartesian co-ordinates $N_0(x_a,y_c)$. Then we pass to step 3 with figure 2D. A second target appears with known screen co-ordinates $N_1(k,l)$ close to the screen maximal co-ordinates. Here also, the operator has to produce an impact to the plate opposite to the target so that the calibrating software can determines the corresponding physical Cartesian co-ordinates $N_1(x_b,y_d)$. The software has then sufficient information to determine the screen co-ordinates (N_{qx},N_{qy}) of any other impact from its physical co-ordinates (x_r,y_r) according to the following correspondence formula:

$$\left\{\begin{array}{l} N_{qx}=i+(k-i)\dfrac{(x_r-x_a)}{(x_b-x_a)} \\ N_{qy}=j+(l-j)\dfrac{(y_r-y_d)}{(y_c-y_d)} \end{array}\right\}$$

It remains to check that the calibration is satisfactory. It is the purpose of step 4 illustrated by figure 2E: a target appears at the screen middle, for example of screen co-ordinates (400,300) for a screen displaying with a maximal SVGA definition of (800,600). Here also the operator has to produce an impact opposite to the target; this fact leads to steps 5 illustrated by the figure 2F. A dialog box appears on one side, expected screen co-ordinates ATX and ATY, i.e. (400,300) and on the other side deduced screen co-

ordinates RESX and RESY of the above correspondence formula. When deviation exceeds certain threshold, practically a dozen of pixels, it is advised to redo the procedure.

Once the homothetic correspondence between the plate and graphic screen is established, any impact to any given location of the plate, located opposite to the screen may be visualized on the screen with a graphic pointer. Pilot software then allows one to do such that these impacts are interpreted as events of another pointing peripheral, such as for example a mouse-type peripheral. An impact to the plate will be then interpreted as a mouse click or double-click at the location of the impact screen co-ordinates.

If these co-ordinates correspond to the place of an icon associated with other peripherals, particularly of the keyboard type. This fact is very useful when browsing the Internet network and desiring communicating information requiring the entry of alphanumeric characters.

The invention provides for this purpose a floating and always accessible menu bar, shown in figure 3B. This bar is placed at a screen corner. It contains a limited number of icons for masking the least graphic surface possible. However, if notwithstanding this minimal occupation, the bar masked a document in the background, it is possible to move it to another corner of the screen with icon K03 representing a menu bar associated with an arrow indicating the corner wherein the floating menu bar will be during the next impact to this icon. Successive impacts to this icon will have for effect the motion of the bar to the four corners of the screen, the motion to another corner is done in counter-clockwise direction.

Second visible icon K04 in figure 3B is a keyboard. An impact to the plate opposite to this icon triggers the appearance of an alphanumeric keyboard of figure 3A. To maximize the surface occupied by the keys, such that the association of an impact with a key is reliable without having to cover the entire screen surface, the keyboard contains a restraint

number of alphanumeric keys according to a configurable format, French with AZERTY type or American with QWERTY type.

The keyboard occupies entire width of the screen, but only one third of its height. There also, an additional key K01 is provided to move it up or down in the event that it would mask the interested document located in the background. The key represents a keyboard with an arrow above or below depending whether the keyboard is respectively in the lower part or higher part of the screen.

Another aspect of the invention relates to the addition of a function allowing one to limit the plate portion on which the impacts emulate the events of the mouse-type graphic pointer (click, double-click, etc...). In fact, it is desirable in public area to limit the field of action of non-scrupulous users. In particular, the function aims to prevent a user from leaving the software application by clicking in the closing icons or in the rolling menus. For that, it is enough to define a screen zone authorizing the interpretation of the impacts as events of the peripheral mouse. An impact made outside the authorized zone will eventually trigger the display of a message. The message may be shown in the form of a graphic box whose contour delimits the authorized zone.

Procedure for defining the authorized zone is illustrated in figure 2A. It shows a dialog box. The authorized zone is defined, either by directly inputting screen co-ordinates (X,Y) of the upper left corner followed with data of the width L and height H of the zone in pixels, or by directly acquiring these data by successively activating the keys "acquire" and by making acoustic impacts to the corresponding upper left and lower right corners of the zone to be defined. Impacts are then converted into screen co-ordinates, from which data are extracted, which are displayed in the fields provided for direct acquisition of values.

This dialog box also contains a schematic image of the plate allowing one to configure the acquisition of co-ordinates. Symbols p and q defining Cartesian co-ordinates

of the sensors in this description are replaced in the figure respectively with symbols CH and CV.

CLAIMS

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1. Device for acquiring position co-ordinates of a mechanical wave source eventually generated by an impact to the surface of a finite size plate (PLQ) comprising a set of acoustic sensors (PZT00 to PZT11) each formed with a pair of piezoelectric transducers (PZTa, PZTb) located in opposition on either side of the plate, the device comprising processing means for determining source co-ordinates by analyzing the difference in propagation time of acoustic waves generated by the source to different sensors, device characterized by the fact that, processing means comprise in association with each sensor (PZT00 to PZT11) a respective electronic circuit comprising in cascade means for digitizing the amplified signal around a pre-determined frequency, associated with means for limiting the digitization to a temporal window starting before the acoustic waves arrive to a sensor and ending after acoustic waves arrive to said sensor.

2. Device according to claim 1 characterized by the fact that sensors are in the number of four and piezoelectric transducers of each sensor are piezoelectric ceramic disks or plates bonded on either side of the plate, such that the four sensors form on the plate the apexes of a rectangle whose center (O) is the co-ordinate origin of a Cartesian system whose axes x and y are parallel to at least two sides of the rectangle defined by the four sensors.

3. Device according to claims 1 or 2 characterized by the fact that the determination of position co-ordinates is done with a triplet of sensors taken from the four sensors, said triplet corresponding to three sensors closest to the source, each triplet being in charge of the detection of co-ordinates in a given quadrant of the Cartesian system defined by the sensors.

4. Device according to claims 1 to 3 characterized by the fact that localization of an interaction point of the source with the plate consists of extracting the ultrasound frequency component in the proximity of 100 kHz generated by the impact of a hard object such as finger nail, metal key, ball-point pen, hard plastic material in the form of a stick and determining the largest of the differences in absolute value of the propagation time between two sensors of two first pairs (PZT00,PZT01) identified by $g_x = 0$ or (PZT10,PZT11) identified by $g_x = 1$, on the one hand, and two pairs of two sensors (PZT00,PZT10) identified by $g_y = 0$ or (PZT01,PZT11) identified by $g_y = 1$, on the other hand, such that Cartesian co-ordinates of the impact point (x_r, y_r) on the plate are provided by the formula:

$$x_r = (-1)^{g_x} \frac{\Delta tx_g \left(q \sqrt{p^2 v^2 (4 p^2 - v^2 \Delta tx_g^2)(4 p^2 + 4 q^2 - v^2 (\Delta tx_g - \Delta ty_g)^2) \Delta ty_g^2 (4 q^2 - v^2 \Delta ty_g^2)} + p^2 v^2 \Delta ty_g^2 (-4 q^2 + v^2 \Delta ty_g (-\Delta tx_g + \Delta ty_g))\right)}{4 p \Delta ty_g (q^2 v^2 \Delta tx_g^2 + p^2 (-4 q^2 + v^2 \Delta ty_g^2))}$$

$$y_r = (-1)^{g_y} \frac{q v^2 \Delta tx_g (-4 p^2 + v^2 \Delta tx_g (\Delta tx_g - \Delta ty_g)) \Delta ty_g + \sqrt{p^2 v^2 (4 p^2 - v^2 \Delta tx_g^2)(4 p^2 + 4 q^2 - v^2 (\Delta tx_g - \Delta ty_g)^2) \Delta ty_g^2 (4 q^2 - v^2 \Delta ty_g^2)}}{4 (q^2 v^2 \Delta tx_g^2 + p^2 (-4 q^2 + v^2 \Delta ty_g^2))}$$

wherein p and q designate the position of sensors relative to the rectangle center O e, v the mode speed of the selected plate by the particular mounting of the transducer pair forming a sensor, Δtx_g (respectively Δty_g) the difference in propagation time of the wave pack generated by the impact between the sensors of one of the first two pairs (respectively of one of the two following pairs), selected by the index value g_x (respectively g_y) equal to 0 if the co-ordinate y_r (respectively x_r) is negative and 1 if otherwise and writing Δtx_0 if $g_x = 0$ or Δtx_1 if $g_x = 1$ (respectively Δty_0 if $g_y = 0$ or Δty_1 if $g_y = 1$).

5. Device according to claims 1 to 4 characterized by the fact that said electronic circuits associated with sensors PZTij (i or j equal to 0 or 1) comprise in cascade two wide band pre-amplifiers stage (A1ij, A2ij), a selective amplifier stage (FCHij) centered on a frequency close to 100 kHz, a square exponentiation stage (Sqij), a crest detector stage (ENVLij), an integrator stage (INTGRij), a PMOSij stage for adapting to a logic level supplying a synchronization signal SYNCij, said synchronization signal SYNCij triggering by a logic

transition, a scale FFij in charge of controlling the stop of the analog digital converter CANij and the transfer into memory FIFOij (first in, first out) of the signal digitized value issued from selective filter FCHij directed to the converter CANij.

6. Device according to claims 1 to 5 characterized by the fact that processing means comprise downstream of said electronic circuits a programmable logic module (wavepro4) piloted by micro-controller µC of an arithmetic and logic unit, with input/output ports operating on interruption, a RAM memory, a ROM memory, a real time clock, ports for capturing time of commutation of signals SYNCij, communication ports, data bus and address bus.

7. Device according to claims 1 to 6 characterized by the fact that micro-controller µC has software means for measuring time interval TTij separating the wave pack head t_{HDij} from the rising front of the synchronization signal SYNCij, said software means consisting of determining the time of passage to zero of the digitized signal starting from the end of the digitization window beginning on the rising front of SYNCij, while a decreasing test of successive sum values of the amplitudes between passages to zero, i.e. a test of the signal average value per half-period, decides the continuation of the search algorithm of the time t_{HDij}. When the average value over a half-period is equal to the output value of the sampler in the absence of signal, to within a deviation, the algorithm is stopped, and the average value is considered as being the origin time t_{HDij} of the pack.

8. Device according to claims 1 to 7 characterized by the fact that values of bits g_x and g_y are determined with the following formulas:

$$\left\{\begin{array}{l} \Delta t_{x0} = abs\left[TT_{01} - TT_{00} + (-1)^{SS_{x0}} XBUF \& \Delta tx_{S0}\right] \\ \Delta tx_{S0} = \left(\left(SR_{01} \& \overline{SR_{00}}\right) \# \left(\overline{SR_{01}} \& SR_{00}\right)\right) \\ \Delta t_{x1} = abs\left[TT_{11} - TT_{10} + (-1)^{SS_{x1}} XBUF \& \Delta tx_{S1}\right] \\ \Delta tx_{S1} = \left(\left(SR_{1} \& \overline{SR_{0}}\right) \# \left(\overline{SR_{1}} \& SR_{0}\right)\right) \\ SS_{x0} = SR_{00} \& \overline{SR_{01}} \\ SS_{x1} = SR_{0} \& \overline{SR_{1}} \end{array}\right\} \left\{\begin{array}{l} \Delta t_{y0} = abs\left[TT_{10} - TT_{00} + (-1)^{SS_{y0}} XBUF \& \Delta ty_{S0}\right] \\ \Delta ty_{S0} = \left(\left(SR_{0} \& \overline{SR_{00}}\right) \# \left(\overline{SR_{0}} \& SR_{00}\right)\right) \\ \Delta t_{y1} = abs\left[TT_{11} - TT_{01} + (-1)^{SS_{y1}} XBUF \& \Delta ty_{S1}\right] \\ \Delta ty_{S1} = \left(\left(SR_{1} \& \overline{SR_{01}}\right) \# \left(\overline{SR_{1}} \& SR_{01}\right)\right) \\ SS_{y0} = SR_{00} \& \overline{SR_{0}} \\ SS_{y1} = SR_{01} \& \overline{SR_{1}} \end{array}\right\}$$

$g_x = 0$ if $\Delta t_{y0} > \Delta t_{y1}$ and $[TT_{10} - TT_{00} + (-1)^{SS_{y0}} . XBUF \ \& \ \Delta ty_{S_0}] < 0$

or if $\Delta t_{y1} > \Delta t_{y0}$ and $[TT_{11} - TT_{01} + (-1)^{SS_{y1}} . XBUF \ \& \ \Delta ty_{S_1}] < 0$

otherwise gx = 1

$g_y = 0$ if $\Delta T_{x0} \geq \Delta T_{x1}$ and $[TT_{01} - TT_{00} + (-1)^{SS_{x0}} . XBUF \ \& \ \Delta tx_{S_0}] < 0$

or if $\Delta t_{x1} \geq \Delta t_{x0}$ and $[TT_{11} - TT_{10} + (-1)^{SS_{x1}} . XBUF \ \& \ \Delta tx_{S_1}] < 0$

otherwise $g_y = 1$

9. Device according to claims 1 to 8 characterized by the fact that acoustic plate is a laminated glass made up with an assembly of plates of the same thickness, bonded to each other with a polymer film.

10. Device according to claims 1 to 9 characterized by the fact that piezoelectric transducers of a sensor are ferro-electric ceramics whose polarization vectors are symmetrically directed relative to the plate thickness and electrical connections are in parallel.

11. Device according to claims 1 to 9 characterized by the fact that piezoelectric transducers of a sensor are ferro-electric ceramics whose polarization vectors are non-symmetrically directed relative to the plate thickness and electrical connections are non-parallel.

12. Device according to claims 1 to 11 characterized by the fact that piezoelectric ceramics are disks or plates whose lower electrode, in contact with the plate, is reduced to a small

portion of the upper surface, while remaining isolated from the upper electrode by an insulating electrical guard strip.

13. Device according to claims 1 to 11 characterized by the fact that one of the sensors for example PZT10 is suited to be commuted into a transmitter of an ultrasound wave pack in order to trigger the measurement of the acoustic wave propagation speed in at least two different directions provided by the positions of other sensors.

14. Device according to anyone of previous claims constituting a peripheral interface with a computer equipped with a screen.

15. Device according to claim 14 characterized by the fact that acoustic plate also is used as visualization screen with diffusion of the projected light, either by frosting of at least one of the surfaces of the glass plates, or by using an eventually colored translucent polymer film, combined with a concentration effect of the light by means of a Fresnel lens.

16. Device according to claims 14 and 15 characterized by the fact that axes of the screen system and the acoustic plate are co-linear.

17. Device according to claims 14 to 16 characterized by the fact that a homothetic correspondence between a pixel (N_{qx},N_{qy}) of the screen system and a physical point (x_r,y_r) of the plate opposite to the graphic pixel is established with an automated calibration according to following operations:

• a display by the software of a target in various positions of knew screen co-ordinates and measurement of corresponding physical co-ordinates. For example, a first target is displayed in N_0(ij) wherein i and j are screen co-ordinates, close to the origin of graphic co-ordinates. This target is displayed on the acoustic plate with real co-ordinates $N_0(x_a,y_c)$. An

impact made opposite to the target allows one to collect these real co-ordinates via the acquisition device. A second target is then displayed in $N_1(k,l)$ close to the maximal co-ordinates of the graphic interface. Corresponding real co-ordinates $N_1(x_b,y_d)$ are obtained with an impact opposite to the target. Graphic co-ordinates (N_{qx},N_{qy}) of a pixel of real co-ordinates (x_r,y_r) may then be deduced from the formula:

$$\left\{\begin{array}{l} N_{qx}=i+(k-i)\dfrac{(x_r-x_a)}{(x_b-x_a)} \\ N_{qy}=j+(l-j)\dfrac{(y_r-y_d)}{(y_c-y_d)} \end{array}\right\}$$

• a reference target is displayed the last time at the graphic screen center, the impact made opposite to the target is converted into screen co-ordinates according to the above formula. Calculated position is compared to the reference position. If the deviation is lower than a certain threshold. Calibrating operation is validated. Otherwise it is re-conducted.

18. Device according to claims 1 to 17 characterized by the fact that the acoustic plate is made up with a graphic pointing peripheral capable of emulating another pointing peripheral such as for example a mouse-type peripheral, an impact to the plate in a given position being then interpreted according to a particular coding, as a click or a double-click made on corresponding screen co-ordinates and triggering the execution of programs associated with an icon located in opposition to the impact.

19. Device according to claims 1 to 18 characterized by the fact that emulation zone of the mouse events (click, double-click, etc...) is limited to an authorized portion of the screen zone showing in the form of a rectangle defined by co-ordinates X,Y in pixels of one of its corners as well as its width L and its height H in pixel, these values, which can be directly captured with keyboard or which can be deduced with acquisition of the co-ordinates of impacts in the corners of the authorized zone to be defined.

20. Device according to claims 1 to 19 characterized by the fact that it is equipped with software means allowing one to make floating tool bar, accessible in permanence, made up with several icons K03, K04 ensuring during an impact made to them:

• the appearance (K04) on the screen an alphanumeric keyboard whose two of its keys K01 and K02 respectively provide its bottom to top motion as well as its reduction to the floating menu bar,

• the rapid and circular motion (K03) of the tool bar in one of the four corners of the screen designated by the arrow direction shown in the icon.

21. Device according to claims 1 to 20 characterized by the fact that it has software means so that the plate portion, which is not used as screen, also is interactive and is configured as an extension of the screen zone, particularly an impact made on the left (respectively on the right, above, below) of the screen zone moves the screen content to the right (respectively to the left, below, above), allowing one to read the document with size much larger than the screen zone size.

22. Device according to claims 1 to 21 characterized by the fact that it has software means so that the portion of the plate, which is not used as screen, is considered as a special zone allowing one to leave or to commute all software application administrating the execution of the program groups associated with various zones of the plate located outside the screen. Inversely, the system has software means so that any impact made to the plate outside the screen zone is associated with the execution of a chosen application, administrator of the working space located outside the screen, such as for example the application wherein, for the homothetic correspondence established between the pixels of a digital photo of the acoustic plate and the physical co-ordinates of these pixels on the acoustic plate, program groups are executed consecutive to an impact on a given zone of the plate.

23. Device according to claims 14 to 22 characterized by the fact that it is equipped with software means such as client-server type protocols allowing the graphic interface to be connected, via a modem of a network card, to a supplier of Internet access.

24. Device according to claims 14 to 22 characterized by the fact that it contains software means allowing one to re-actualizing the multimedia content (image, sound, video) available in the host computer of the graphic interface from a distant computer.

25. Device according to claims 1 to 24 characterized by the fact that electronic circuits associated with respective sensors PZTij comprise downstream of said wide band amplification means A2ij a derivation to frequency enrichment means of the audible acoustic signal generated by the impact to the plate, as well as means for re-converting the enriched signal into analog signal of a percussion instrument in the heart of a symphony composition, or the noise of an animal or a natural event, said enrichment means being used at the same time IntHF were first of the four synchronization signals SYNCij commutes to logic level.

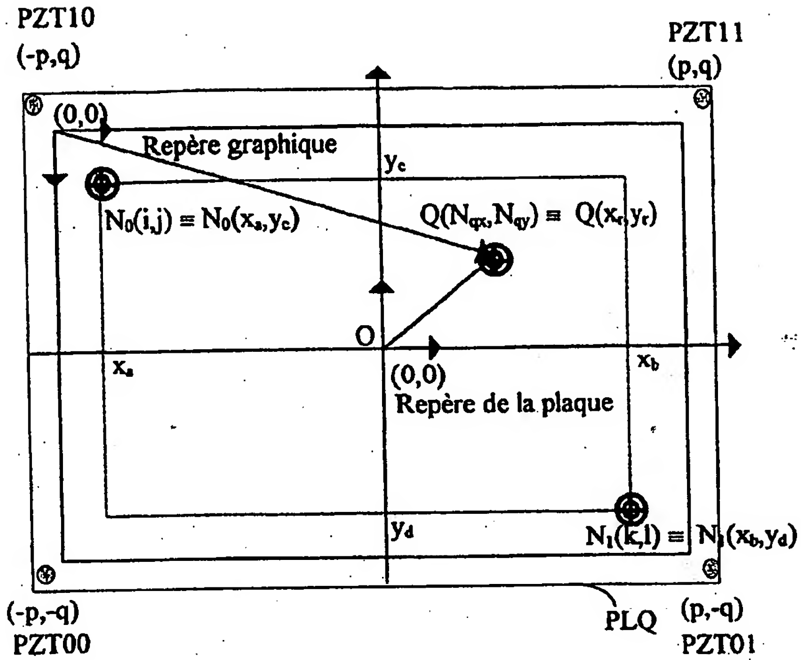

PZT10
(-p,q)
PZT11
(p,q)
(0,0)
Repère graphique
y_c
$N_0(i,j) \equiv N_0(x_a,y_c)$
$Q(N_{qx},N_{qy}) \equiv Q(x_r,y_r)$
O
x_a
x_b
(0,0)
Repère de la plaque
y_d
$N_1(k,l) \equiv N_1(x_b,y_d)$
(-p,-q)
PZT00
PLQ
(p,-q)
PZT01

FIG - 1

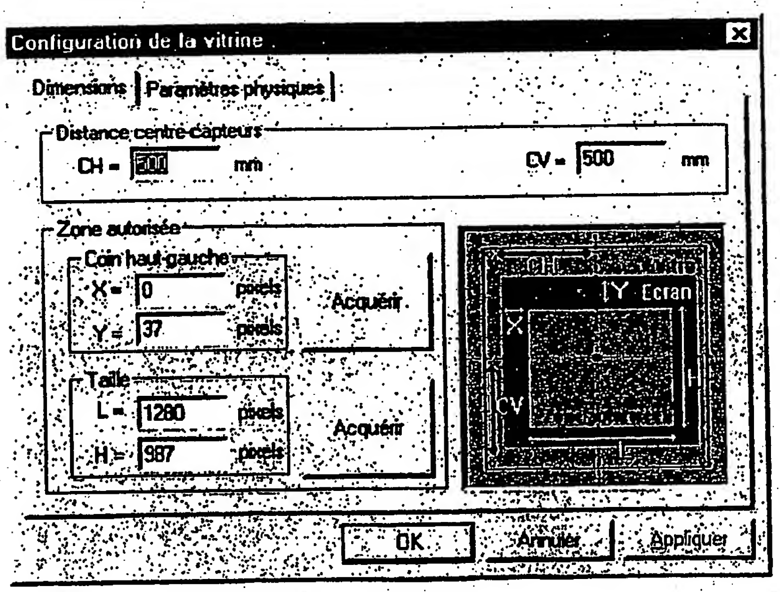

Configuration de la vitrine
Dimensions
Paramètres physiques
Distance centre capteurs
CH = 500 mm
CV = 500 mm
Zone autorisée
Coin haut gauche
X = 0 pixels
Y = 37 pixels
Acquérir
Taille
L = 1280 pixels
H = 987 pixels
Acquérir
Y Ecran
X
CV
H
OK
Annuler
Appliquer

FIG – 2A

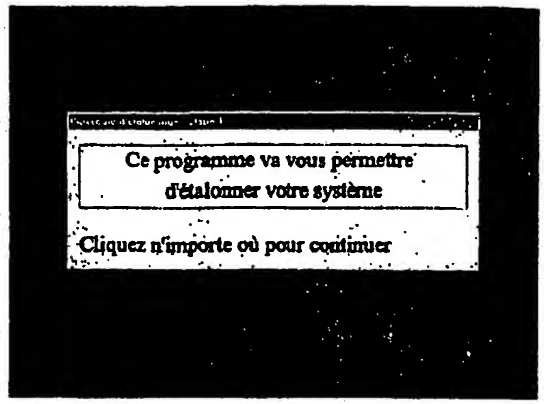


FIG – 2B

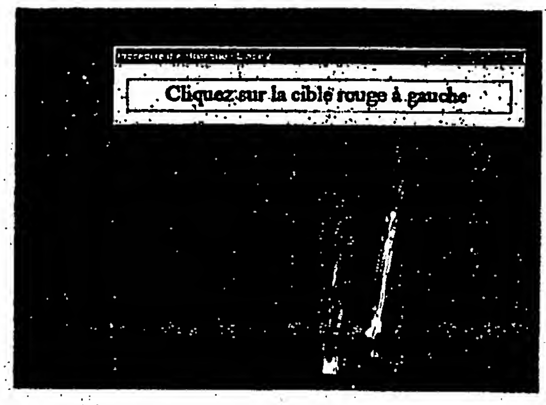


FIG – 2C

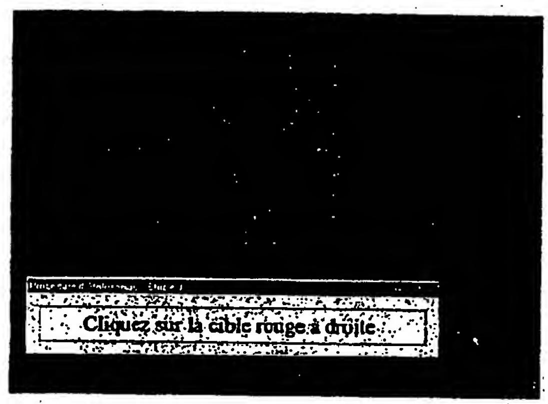


FIG – 2D

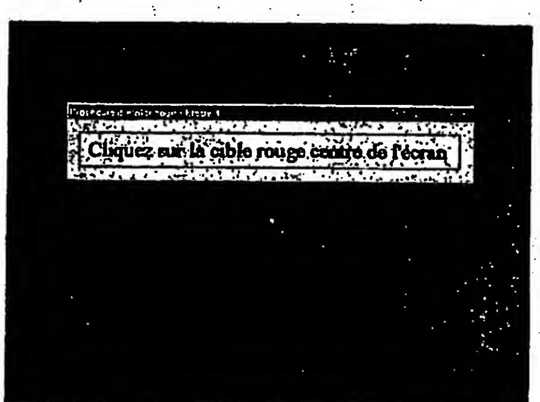


FIG – 2E

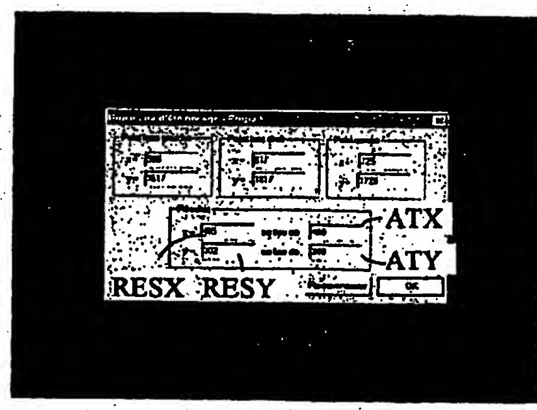


FIG – 2F

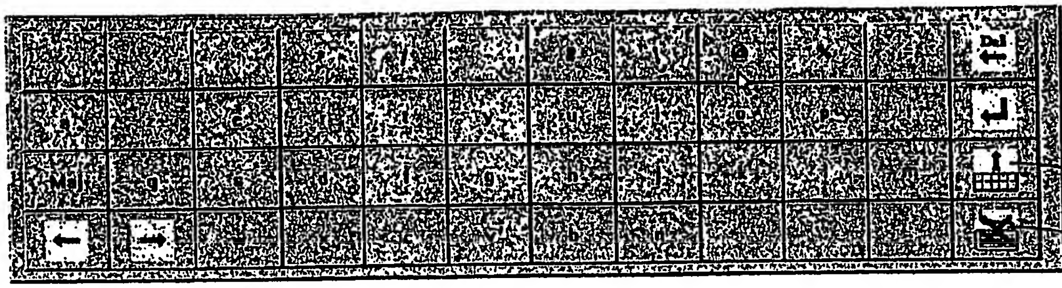


FIG - 3 A

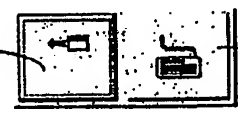


FIG - 3 B

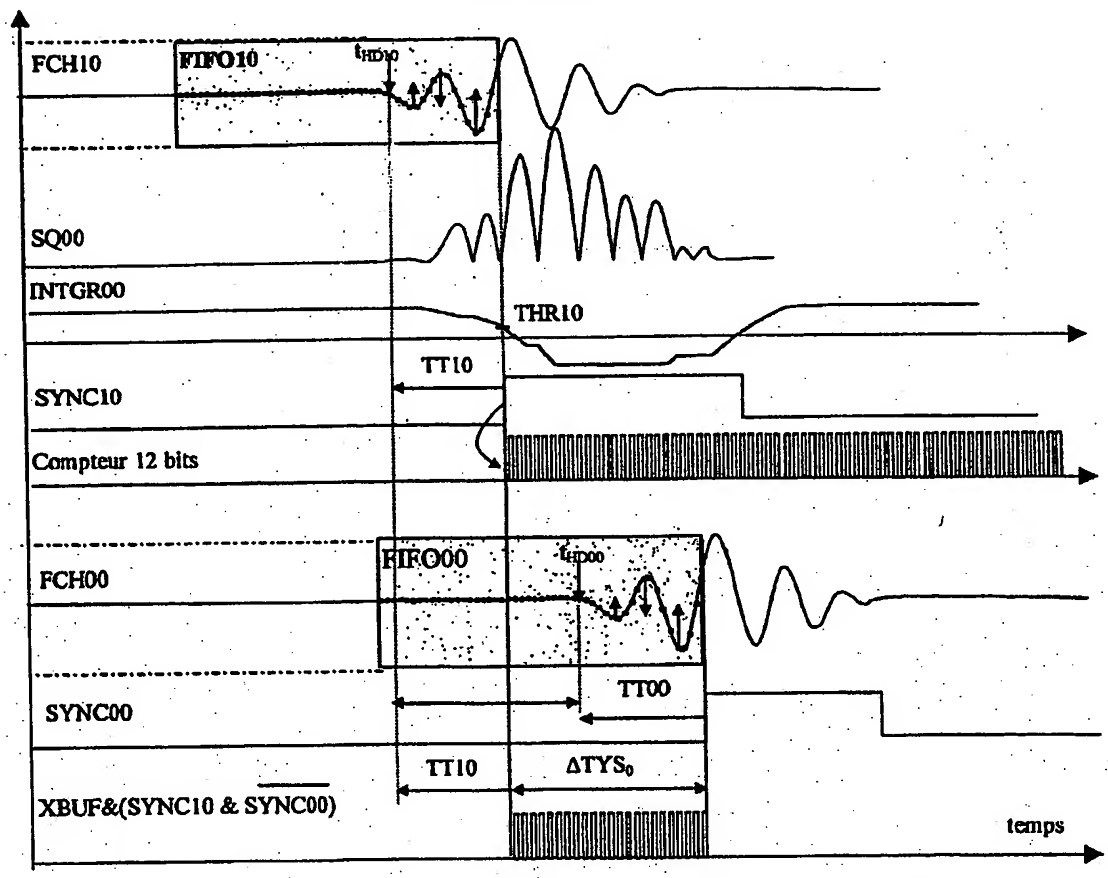


FIG - 4

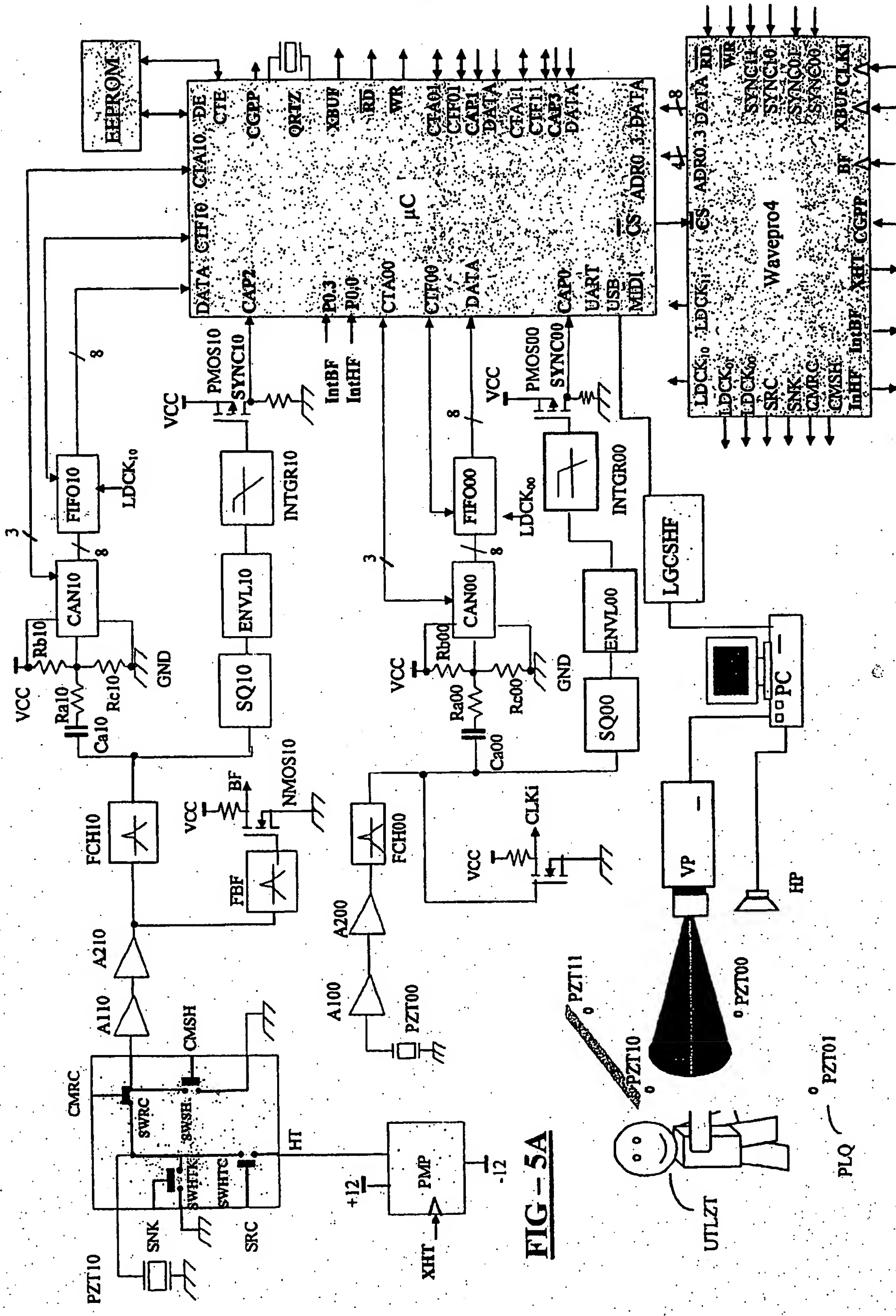

EEPROM
μC
DATA
CTF10
CTA10
DE
CTE
CGPP
QRTZ
XBUF
RD
WR
CTA01
CTF01
CAP1
CTA11
CTF11
CAP3
CAP2
P0.3
P0.0
CTA00
CTF00
CAP0
UART
USB
MIDI
CS
ADR0..3
Wavepro4
LDCK10
LDCK01
LDCK00
LDCK11
SRC
SNK
CMRC
CMSH
IntHF
IntBF
XHT
CGPP
BF
XBUFCLKi
SYNC11
SYNC10
SYNC01
SYNC00
IntBF
IntHF
PMOS10
SYNC10
PMOS00
SYNC00
VCC
GND
FIFO10
FIFO00
CAN10
CAN00
INTGR10
INTGR00
ENVL10
ENVL00
SQ10
SQ00
LGCSHF
PC
VP
HP
Rb10
Ra10
Rc10
Ca10
Rb00
Ra00
Rc00
Ca00
FCH10
FCH00
FBF
NMOS10
CLKi
A210
A110
A200
A100
PZT00
PZT10
PZT11
PZT01
CMRC
CMSH
SWRC
SWSH
SWHTK
SWHTC
SNK
SRC
HT
PMP
+12
-12
XHT
UTLZT
PLQ

FIG – 5A

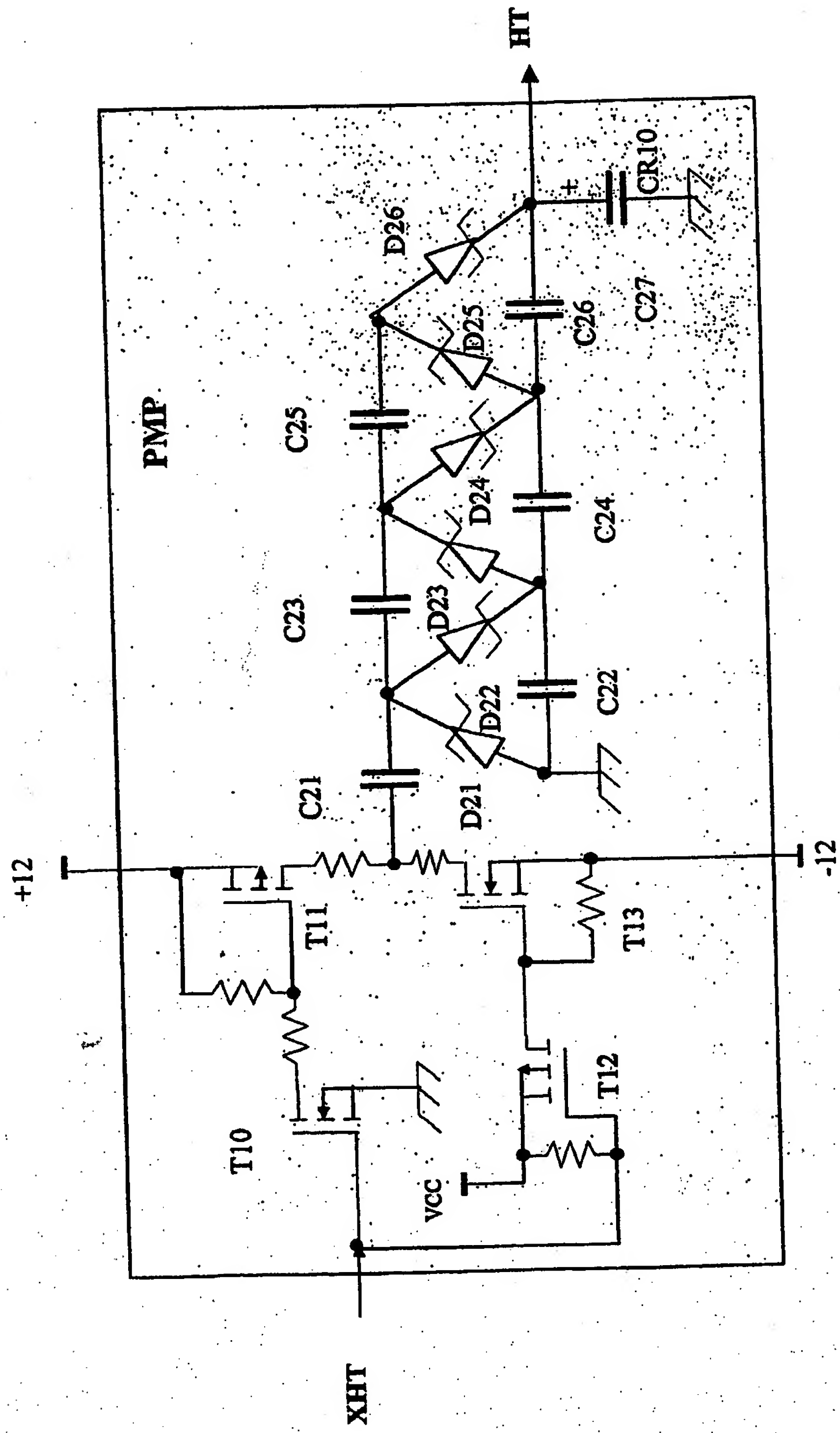

HT
PMP
CR10
+
C27
C26
D26
D25
C25
D24
C24
C23
D23
C22
D22
C21
D21
+12
-12
T11
T13
T12
T10
VCC
XHT

FIG - 5B

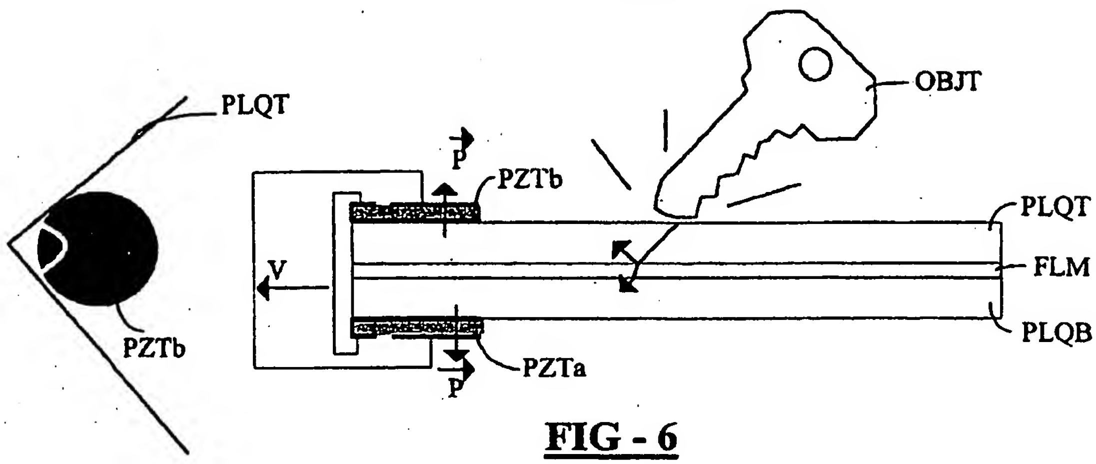


FIG - 6

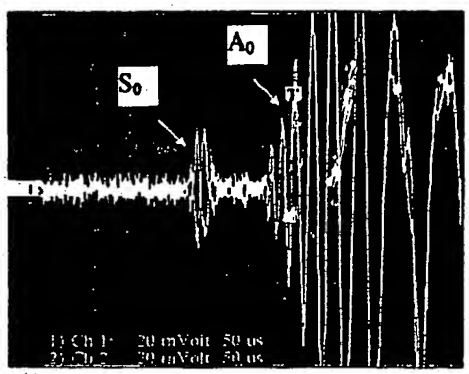


FIG – 7A

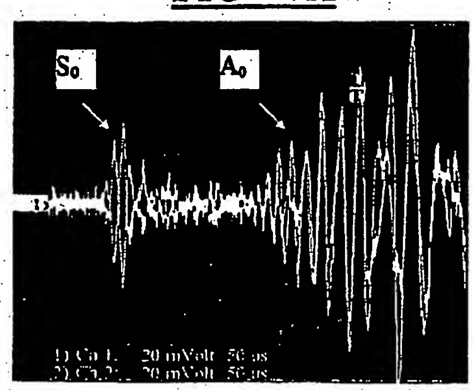


FIG - 7B

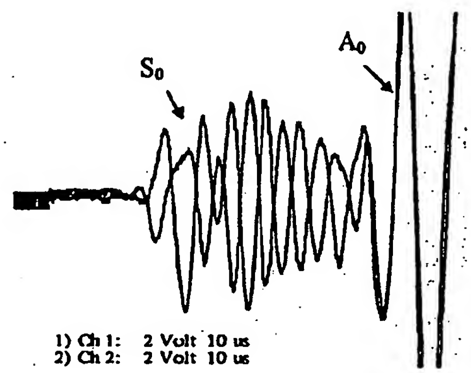


FIG - 7C

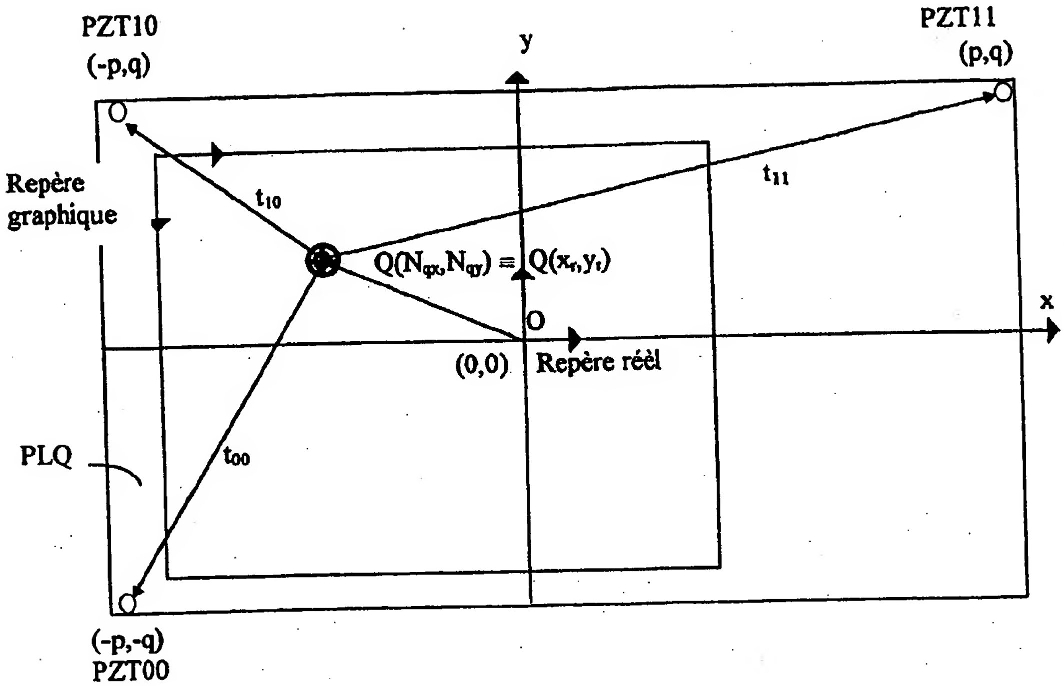

PZT10
(-p,q)
PZT11
(p,q)
y
x
Repère graphique
t10
t11
Q(Nqx,Nqy) ≡ Q(xr,yr)
O
(0,0)
Repère réel
PLQ
t00
(-p,-q)
PZT00

FIG - 8

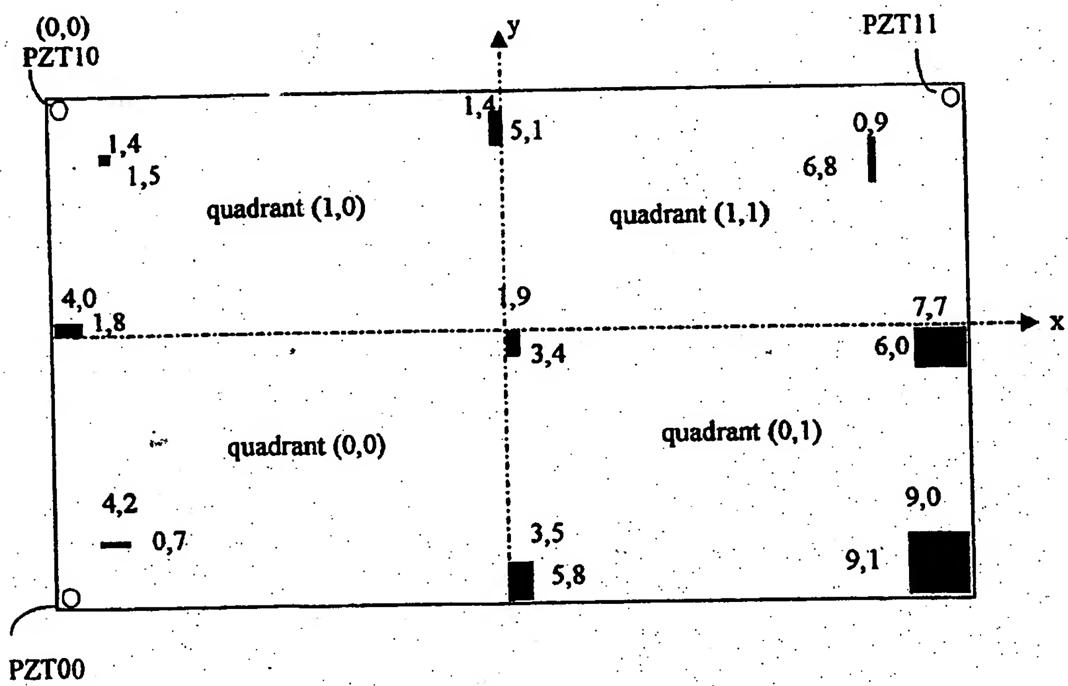
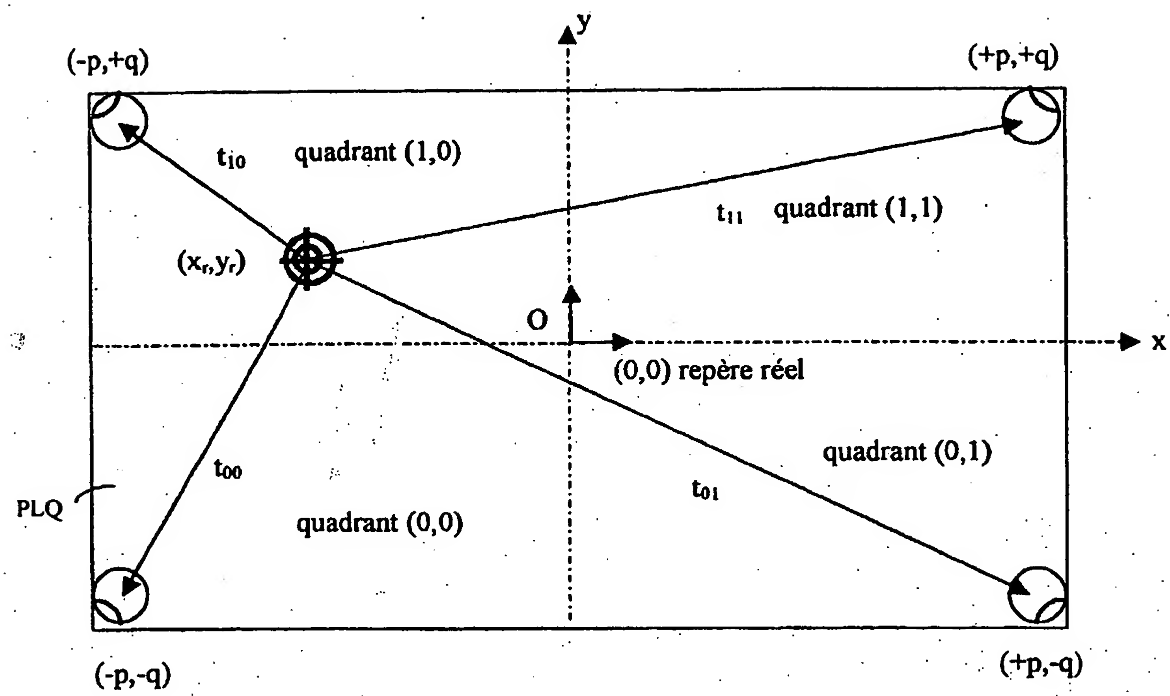

(0,0)
PZT10
PZT11
y
x
1,4
5,1
1,4
1,5
0,9
6,8
quadrant (1,0)
quadrant (1,1)
4,0
1,8
1,9
3,4
7,7
6,0
quadrant (0,0)
quadrant (0,1)
4,2
0,7
3,5
5,8
9,0
9,1
PZT00

FIG - 9



y
(-p,+q)
(+p,+q)
t_{10}
quadrant (1,0)
t_{11}
quadrant (1,1)
(x_r,y_r)
O
x
(0,0) repère réel
quadrant (0,1)
t_{00}
t_{01}
PLQ
quadrant (0,0)
(-p,-q)
(+p,-q)

FIG - 10

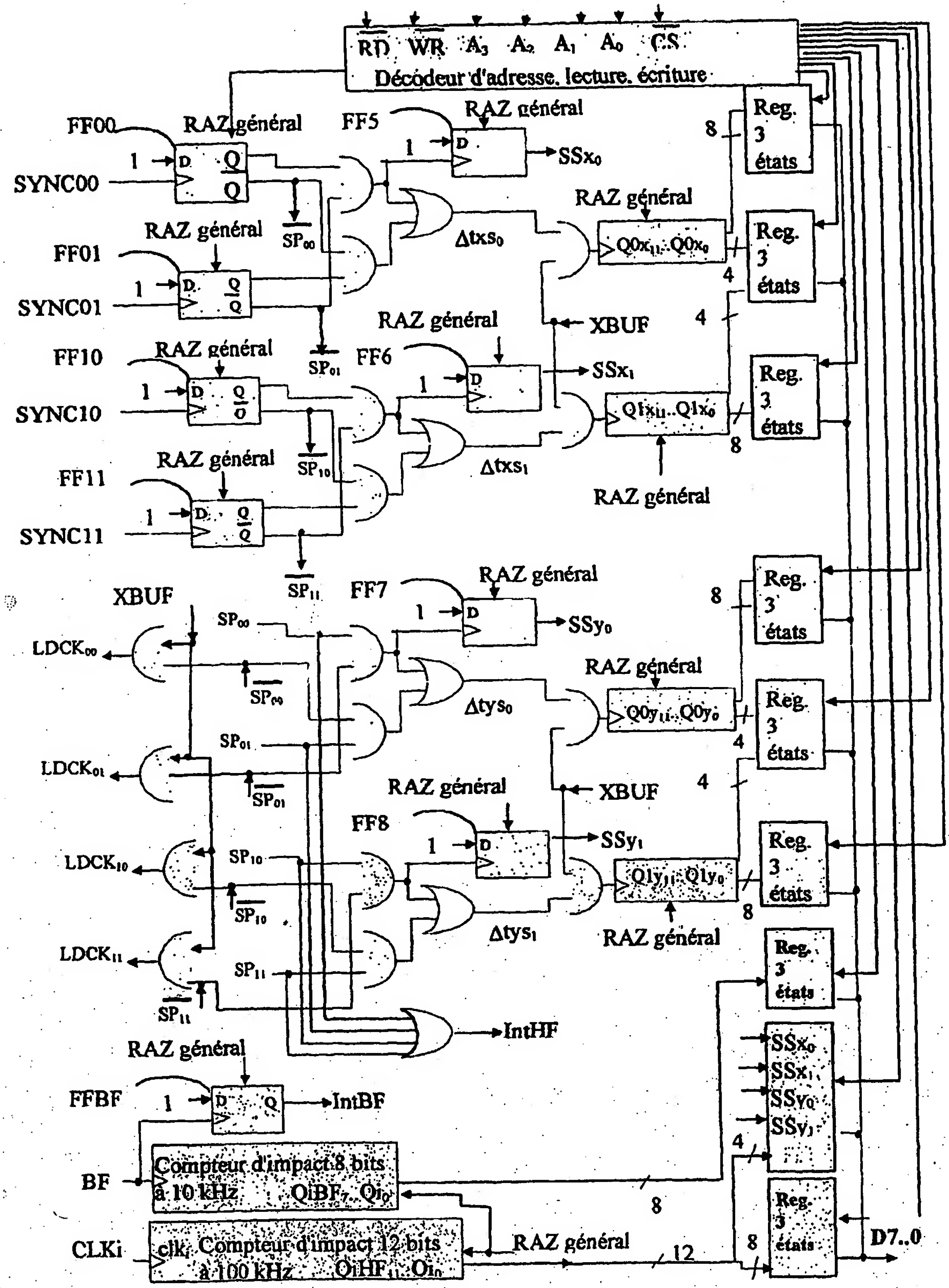

RD WR A3 A2 A1 A0 CS
Décodeur d'adresse, lecture, écriture
FF00
RAZ général
SYNC00
FF01
SYNC01
FF10
SYNC10
FF11
SYNC11
FF5
SSx0
FF6
SSx1
FF7
SSy0
FF8
SSy1
Δtxs0
Δtxs1
Δtys0
Δtys1
Q0x11..Q0x0
Q1x11..Q1x0
Q0y11..Q0y0
Q1y11..Q1y0
XBUF
Reg. 3 états
LDCK00
LDCK01
LDCK10
LDCK11
SP00
SP01
SP10
SP11
IntHF
FFBF
IntBF
BF
Compteur d'impact 8 bits à 10 kHz QiBF7..Qi0
CLKi
clki Compteur d'impact 12 bits à 100 kHz QiHF11..Qi0
SSx0
SSx1
SSy0
SSy1
D7..0

FIG - 11

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/FR 01/02088

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K11/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 787 608 A (CLIC CHOC MULTIMEDIA) 23 June 2000 (2000-06-23) cited in the application the whole document -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2001	26/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Clarelli, N

INTERNATIONAL SEARCH REPORT

Inte al Application No
PCT/FR 01/02088

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
FR 2787608	A	23-06-2000	FR	2787608 A1	23-06-2000
			AU	1785300 A	12-07-2000
			EP	1141884 A1	10-10-2001
			WO	0038104 A1	29-06-2000